Articles

Outcome, Transport Times, and Costs of Patients Evacuated by Helicopter Versus Fixed-Wing Aircraft

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We determined the differences in transport times and costs for patients transported by fixed-wing aircraft versus helicopter at ranges of 101 to 150 radial miles, where fixed-wing and helicopter in-hospital transports commonly overlap. Statistical analysis failed to show a significant difference between the trauma-care patients transported by helicopter (n = 109) and those transported by fixed-wing (n = 86) for age, injury severity score, hospital length of stay, hospital mortality, or discharge disability score. The times in returning patients to the receiving hospital by helicopter (n = 104) versus fixed-wing (n = 509) did not differ significantly. Helicopter transport costs per mile ($24), however, were 400% higher than those of fixed-wing aircraft with its associated ground ambulance transport costs ($6). Thus, helicopter transport is economically unjustified for interhospital transports exceeding 100 radial miles when an efficient fixed-wing service exists.

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The development of major trauma referral centers has had a positive effect in improving the outcome for severely injured patients.[1-3] To be effective, these centers must care for a large number of critically injured patients.[4] Field triage systems have been developed allowing patients who would benefit from care given at a major trauma center to be rapidly identified and transported directly to these facilities.[5-7]

Recently there has been a rapid growth in helicopter and fixed-wing aeromedical programs.[8,9] Aeromedical transport allows the rapid transport of severely injured patients and increases accessibility to needed tertiary care services.[10,11] Frequently the areas served by fixed-wing and helicopter aeromedical transport services overlap. The benefit of the helicopter is that it allows rapid liftoff from the hospital to the scene of injury without the required ground transport associated with fixed-wing transports. The benefits of the fixed-wing service are a faster air speed, longer distances that can be traveled without refueling, greater weather capabilities, lower operating costs, and a better safety record.[12]

Despite proclaimed advantages or disadvantages of helicopter versus fixed-wing transports, the question remains whether the use of helicopter or fixed-wing aircraft to transport patients from similar distances makes a difference in outcome, transport times, or transport costs for patients referred to a major trauma-care center. To date, there are no published studies that have attempted to make this comparison.

Methods

The study hospital is a level I trauma center that operates a helicopter and fixed-wing aeromedical transport service. Two fully dedicated fixed-wing air ambulances are staffed by pilots on site 24 hours a day at a local airport. A flight nurse or physician and an intensive-care-unit nurse make up the on-call team for fixed-wing transports. The fixed-wing, twin-turbine engine, pressurized aircraft (MU-II) averages 340 miles per hour (mph). A fully dedicated single-engine turbine helicopter (Alouette III) is based at the hospital with an on-site pilot, flight nurse, and flight paramedic. The average speed of the helicopter is 115 mph.

In an attempt to delineate any difference in outcome occurring because of the mode of transport (fixed-wing versus helicopter), we compared the cases of all trauma-care patients aeromedically transported from May 1979 through December 1987 who were transported from similar distances to the same level I trauma center. Trauma-care patients were selected because a variety of physiologic and anatomic scores have been developed that would allow for a determination of any differences in injury severity between patients transported by helicopter versus fixed-wing aircraft.[5-7,13] For the study, the trauma-care patients were stratified by transport distance into six groups starting with those transported 75 radial miles or less and increasing by 25-radial-mile increments, with the final group representing patients transported more than 175 radial miles to the study hospital.

The six groups were further condensed into three groups based on distances in which the helicopter was predominantly used ($\leq$100 radial miles), helicopter and fixed-wing usage was similar (101 to 150 radial miles), and fixed-wing transport was predominantly used ($>$150 radial miles). The trauma-care patient groups were then compared by age, injury severity score, hospital length of stay, hospital mortality, and discharge disability score (Table 1).[14]

Following the trauma patient outcome results, transport times for fixed-wing versus helicopter transports for all patients—cardiac, medical, trauma care, obstetric, and pediatric—transported between January 1, 1985, and December 15, 1988, at distances of 101 to 150 radial miles were analyzed. The time of aircraft liftoff was determined from the time the first requesting call was received by the dispatch center until the aircraft first lifted off from either

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the airport (fixed-wing) or the hospital (helicopter). The return time was determined from the time of the first requesting call to the dispatch center until the patient arrived at the destination hospital. Only emergency transports were evaluated. Elective medical transports or those that were delayed because of weather were excluded from the analysis. Ground transport time from the airport to the receiving hospital was included in the total fixed-wing transport times.

Finally, to determine cost differences between helicopter versus fixed-wing transports, the true transport costs per mile of fixed-wing aircraft versus helicopter were calculated for all transports in 1987. The costs included both the direct and indirect costs of all leases, overhead, personnel, equipment, dispatch, fuel, maintenance, medications, and supplies, and a cost per mile to transport patients by helicopter versus fixed-wing aircraft was calculated. A standard ground ambulance transport cost of $370 for transfers between the referring and receiving hospitals and their local airports was incorporated into the costs for fixed-wing transports.

Statistical data are reported as absolute numbers and mean plus or minus standard deviations. All results were tested statistically using the unpaired t test and the χ^2 analysis. Data analysis was considered significant when a P value of less than .05 was obtained.

Results

During the study, 660 trauma-care patients were transported by helicopter and 266 trauma-care patients by fixed-wing aircraft. The average injury severity score for the patients transported by helicopter (23.1 $\pm$ 15.6) was not significantly different from those of patients transported by fixed-wing aircraft (22.8 $\pm$ 14.2). No patient died during transport. Only 1 patient was transported by fixed-wing less than a 75-mile radius, and 510 patients were transferred by helicopter at this range (Table 2). Most patients transported less than 75 miles were transferred by helicopter directly from the accident scene to the referral trauma center. All fixed-wing and helicopter transports greater than 75 radial miles were done as interfacility transports because at this distance it is in the patient's best interest to be first ground-transported to the nearest facility for initial stabilization. For all six groups defined in 25-mile increments (Table 2) and for the three consolidated groups (Table 3), no statistical differences were found between trauma patients aeromedically evacuated by helicopter versus fixed-wing for age, injury severity score, length of hospital stay, hospital mortality, or disability discharge score. Helicopter and fixed-wing transports were commonly found to overlap in the 101- to 150-radial-mile range (Table 3).

We found that for all 613 trauma and nontrauma patients transported at 101 to 150 radial miles, fixed-wing

TABLE 1.—*Discharge Disability Score*

Score		*Definition*
1	Death	
2	Severe disability (complete dependency)	Patients who because of the injuries sustained are dependent on others for even their basic needs such as eating, dressing, and toilet duties
3	Moderate disability (disabled but independent)	Patients who because of the injuries sustained are dependent on others or mechanical devices to carry out more complex but routine daily activities such as climbing, driving, or performing more delicate physical or mental tasks
4	Minor disability	Patients who because of the injuries sustained have persistent minor limitations or complaints but are able to function completely independently and carry out a normal life-style
5	Normal	Patients who are functioning at their preinjury level without limitation or complaints

TABLE 2.—*Clinical Characteristics and Distances Traveled, in 25-Mile Increments, of Trauma Patients Requiring Helicopter (n=660) Versus Fixed-Wing (n=266) Aeromedical Transport**

Transport Distance, Miles	*Patients, No.*	*Age, years*	*Injury Severity Score*	*Hospital Length of Stay, d*	*Hospital Mortality, %*	*Discharge Disability Score†*
<75						
Helicopter	510	30.2±13.7	23.6±15.4	12.5±14.3	57	3.4±1.3
Fixed-wing	1	21	18	6.7	0	3
76-100						
Helicopter	33	29.1±12.1	23.3±13.0	13.4±13.9	6	3.2±1.3
Fixed-wing	16	31.9±17.2	27.7±13.6	16.6±13.3	1	3.2±1.3
101-125						
Helicopter	85	29.7±11.7	19.7±17.0	8.8± 7.8	5	3.9±1.1
Fixed-wing	28	28.8±10.0	18.7±10.2	12.2±12.0	1	3.6±1.0
126-150						
Helicopter	24	25.4±15.1	24.3±15.6	15.7±16.3	4	2.9±1.3
Fixed-wing	58	32.6±15.5	23.5±17.5	11.1±12.5	6	3.5±1.2
151-175						
Helicopter	5	34.6±16.2	25.6± 9.8	15.2± 9.0	0	3.5±1.2
Fixed-wing	76	30.8±12.7	24.5±14.2	12.2±11.7	10	3.0±0.7
>175						
Helicopter	3	22.7± 1.5	33.3±29.4	8.3±10.2	0	4.0±1.7
Fixed-wing	87	32.9±15.1	21.4±12.9	13.0±12.8	8	3.4±1.2

*Except for those of the patient requiring fixed-wing transport of a distance of <75 miles, all values are given as the mean±standard deviation.
†At time of hospital discharge. See Table 1 for the definition of Discharge Disability Score.

TABLE 3.—*Clinical Characteristics and Distances Traveled, in 50-Mile Increments, of Trauma Patients Requiring Helicopter (n=660) Versus Fixed-Wing (n=266) Aeromedical Transport**

Transport Distance, Miles	Patients, No.	Age, years	Injury Severity Score	Hospital Length of Stay, d	Hospital Mortality, No. (%)	Discharge Disability Score†
0-100						
Helicopter	543	30.2±13.6	23.6±15.3	12.5±14.3	63 (12)	3.2±1.3
Fixed-wing	17	31.3±16.8	27.1±13.4	19.4±17.8	1 (6)	3.2±1.2
101-150						
Helicopter	109	28.8±12.6	20.7±16.7	10.2±10.5	9 (8)	3.7±1.2
Fixed-wing	86	31.4±14.0	21.9±15.6	11.4±12.3	7 (8)	3.6±1.2
>150						
Helicopter	8	30.1±13.8	28.5±17.8	12.6± 9.4	0 (0)	3.3±1.2
Fixed-wing	163	31.9±14.0	22.9±13.6	12.6±12.2	18 (11)	3.4±1.3

*All values given as the mean±standard deviation.
†At time of hospital discharge. See Table 1 for the definition of Discharge Disability Score.

TABLE 4.—*Times, in Minutes, of Helicopter Versus Fixed-Wing Aeromedical Transport of Trauma and Nontrauma Patients*

Transport Distance, Radial Miles	All Patients, No.	Helicopter*	Fixed-Wing*	P Value
101-150				
Patients, No.	613	104	509	...
Miles	127	112±13	130±13	<.001
Age, years	37	40±27	36±27	.107
Liftoff time, min†	41	22±14	45±17	<.001
Return time, min‡	204	197±32	205±79	.099
101-125				
Patients, No.	271	84	187	...
Miles	113	107± 6	115± 4	<.001
Age, years	39	41±27	38±25	.327
Liftoff time, min†	39	21±12	46±17	<.001
Return time, min‡	194	189±27	196±69	.250
126-150				
Patients, No.	342	20	322	...
Miles	139	136± 6	139± 9	.101
Age, years	35	38±24	35±28	.595
Liftoff time, min†	44	28±22	45±17	.004
Return time, min‡	211	230±28	210±83	.014

*Values, except number of patients, given as the mean±standard deviation.
†Time from first requesting call to dispatch to the time aircraft lifts off.
‡Time from first requesting call to dispatch to the time patient arrives at receiving hospital.

TABLE 5.—*Speed, Travel Time, and Costs per Mile of Emergency Medical Service (EMS) Helicopters**

EMS Helicopters	Speed, mph	Time of Travel, min: 100 Miles	Time of Travel, min: 150 Miles	Cost/Mile, $†
Alouette III	115	52	78	10.47
Long Ranger L-3	126	48	71	11.59
Astar	144	42	62	9.65
Twin Star	145	41	62	13.56
BO-105	151	40	60	13.35
Agusta 109A	169	36	53	15.54
BK-117	160	38	56	18.47
Bell 222UT	163	37	55	16.70
Dauphin	176	34	51	24.22
S-76	167	36	54	24.66
Bell 212	115	52	78	22.83
Bell 412	141	43	64	26.24

*Adapted from *The 1983 Aeromedical Helicopter Evaluation, First Edition*, with permission.[20]
†These cost figures are for aircraft operations only and do not include medical personnel or equipment costs.

(n = 509) and helicopter (n = 104) transport times were equal in returning patients to the receiving hospitals. Mileage subgroup comparisons showed that there was no difference between helicopter versus fixed-wing in transporting a patient to the receiving hospital in the 101- to 125-mile range. In the 126- to 150-mile range, however, fixed-wing transport was found to be significantly ($P = .014$) faster than helicopter by nearly 20 minutes in transporting the patient to the receiving hospital (Table 4).

Analysis of the cost per mile of fixed-wing versus helicopter transport indicates that the calculated true helicopter costs ($24 per mile) were 400% higher than the true cost of the fixed-wing aircraft and associated ground ambulance charges ($6 per mile).

Discussion

The number of aeromedical transport services has grown dramatically within the past decade. These systems allow critically ill and injured patients to rapidly receive needed life-saving services. In recent years, helicopter aeromedical transport service has come under considerable criticism as being a costly and uneconomic means of delivering health care services.[15] Further, the recent rash of aeromedical helicopter crashes has spurred public concern as to the safety of these services.[16,17] The "Health Policy Agenda for the American People for the Assessment of Health Care Technology" declared,

> The primary goal of the assessment process should be the evaluation of the safety, efficacy, and conditions of use of existing and new health care technologies. Evaluations of the cost-effectiveness of such technologies should also be conducted. . .[18(p1207)]

To this end, our study evaluated the efficacy and cost-effectiveness of helicopter versus fixed-wing aeromedical transports.

We found that at ranges of 101 to 150 radial miles, the outcome for severely traumatized patients as determined by mortality, hospital length of stay, and discharge disability score was not affected by the type of aeromedical transport (helicopter versus fixed-wing). Furthermore, it appears that at this distance range, fixed-wing aircraft is comparable to (101 to 125 radial miles) or faster (126 to 150 radial miles) than helicopters in returning patients to tertiary care treatment centers. Despite these similarities, the study did find that the cost of transporting patients by helicopter is 400% higher than the cost of transporting patients by fixed-wing.

When the accident rates of turbine helicopters are compared with those of fixed-wing turbine aircraft in general aviation, the accident rate for the twin-turbine fixed-wing aircraft is about 25% less than that of a single-turbine helicopter and nearly 50% less than a twin-turbine helicopter.[12] Given that there is no difference in trauma patient outcomes between helicopter and fixed-wing aeromedical transport, that the accident rates are less with fixed-wing versus helicopter transport, and that rotor-wing transport cost is four times that of fixed-wing, rotor-wing transports may be economically unjustified for the interhospital transport of trauma patients more than 100 miles when a medically comparable fixed-wing service is available.

Although the argument can be made that a faster twin-engine rotor-wing aircraft could reduce the travel time from that of the single-turbine engine helicopter used in this study (Table 5), additional analysis shows that except for one helicopter, the use of other faster helicopters would likewise increase the operating costs by 10% to 150%.[19,20] The use of fixed-wing aeromedical services may not be applicable to all regions because of the close proximity of patient transports (<100 radial miles) or the accessibility of sufficient airport runways. Aeromedical helicopter transport programs that frequently fly distances of more than 100 radial miles, however, should consider the development and use of efficient fixed-wing transport services to reduce patient care costs and enhance helicopter availability.

In the final analysis, it must be the responsibility of referring physicians to assure that their patients who require emergency transport not only receive quality medical care, but that the selected mode of transport has been maximized in terms of safety and cost-effectiveness. Further studies should now be done to determine the medical efficacy and cost-effectiveness of helicopter versus ground ambulance transport of patients transported from similar distances. Only through such studies can the safety, efficacy, cost-effectiveness, and proper use of medical transport services be determined.

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